Some Factors Affecting Humus Development in the Northeast

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BECAUSE THE flood problem is increasing and siltation and water-supply problems are becoming critical, the role of humus in watershed management is now receiving more recognition than formerly. Humus is important because its great capacity to absorb water enables it to deter runoff after heavy rainfall. It protects the surface soil from the impact of heavily falling rain, and thereby prevents puddling and clogging of the soil pores, and allows free entry of the water into the underlying soil layers.

Because of the many influencing factors such as climate, soils, vegetation, geographic location, and man-caused disturbances, the analysis of humus data becomes a complex problem. It is recognized that the amount of humus developed under a forest will vary with the latitude and altitude and the associated differences in climate and vegetation (*2*). The basic relationships within a like environment, however will be the same.

For the past several years studies have been made in the Northeast by the Northeastern Forest Experiment Station, U. S. Forest Service, on the possible factors that influence humus development. The purpose of this article is to make known the results of these studies and to point out the importance of the findings to the application of watershed-management practices.

The data presented in this paper were collected on the Allegheny River drainage area in southwestern New York and western Pennsylvania. Supporting information was obtained from surveys covering most of the Northeastern States.

Sampling Method

The data were collected on randomly selected plots distributed throughout the 11,700 squares miles of the Allegheny River watershed. In this area the soils are of the gray-brown podzolic group with a smaller area of podzols on the higher Allegheny Plateau. The principal forest types are northern hardwoods and oak. Lesser areas are occupied by white pine-hemlock and temporary types such as aspen and pin cherry.

A field data form was used on which were listed all factors believed to have an influence on humus development. Some of these items were: Soil drainage and texture class; stand age and stocking; topographic position; aspect; slope; forest type group; and man-caused disturbances. These factors were determined on a 0.1-acre area around the plot center, the area believed to reflect the conditions responsible for the humus observed. Humus types were noted and the depths were measured to the nearest 0.1-inch at the plot center and at a point 6 feet north of it.

Stand age and stocking[1] were determined from the dominant trees. Three stocking classes based on percent of crown closure were recognized: Good, in which 70 to 100 percent of the area was covered by tree canopy; fair, in which 40 to 70 percent of the area was covered; and poor, in which less than 40 percent was covered.

As used here, humus is the upper

[1] Stocking and density, as used in this article, refer to the degree of crown closure rather than the measurement of volume.

portion of the forest floor consisting of decomposed or partially decomposed organic matter which may or may not be mixed with the mineral soil as distinguished from the fresh organic residue (litter) *(4)*. Humus type was classified according to the nomenclature proposed by Heiberg and Chandler *(1)*. The two main types recognized are:

Mull.—A humus layer consisting of mixed organic and mineral matter. Transition to lower horizon not sharp.

Mor.—A humus layer of unincorporated organic material, usually matted or compacted or both, distinctly delimited from the mineral soil unless the latter has been blackened by the washing in of organic matter.

Such organic layers as peats or mucks found on very poorly drained soils are not included in this discussion.

Factors Affecting Humus Development

Although the annual accumulation of litter is obviously a function of the forest stand, the total forest floor, including litter and humus, is an algebraic sum of leaf and twig fall and current accumulation plus the weathering and biotic and chemical factors that bring about decomposition *(5)*. Thus, humus is of a dynamic nature; it is continually undergoing changes brought about by the agencies of accumulation and decomposition *(3)*. The degree to which these agencies exert their influence is controlled largely by stand conditions and other related factors.

Stand age.—The length of time a stand has occupied a given site was found to be a significant factor in humus development (Fig. 1). After a preliminary decline due to the removal of forest cover, the buildup of humus in a young stand is slow because the difference between accumulation and decomposition is small. As the stand grows older and the amount of the raw materials increases, the effects of decomposition are overcome and a deeper humus results. The depth increases with the age of the stand until equilibrium between accumulation and decomposition is reached. This is probably the point at which the maximum tree volume increment is reached *(2)*. The subsequent period shows a gradual decrease in depth because the stand has passed its peak production of leaf fall.

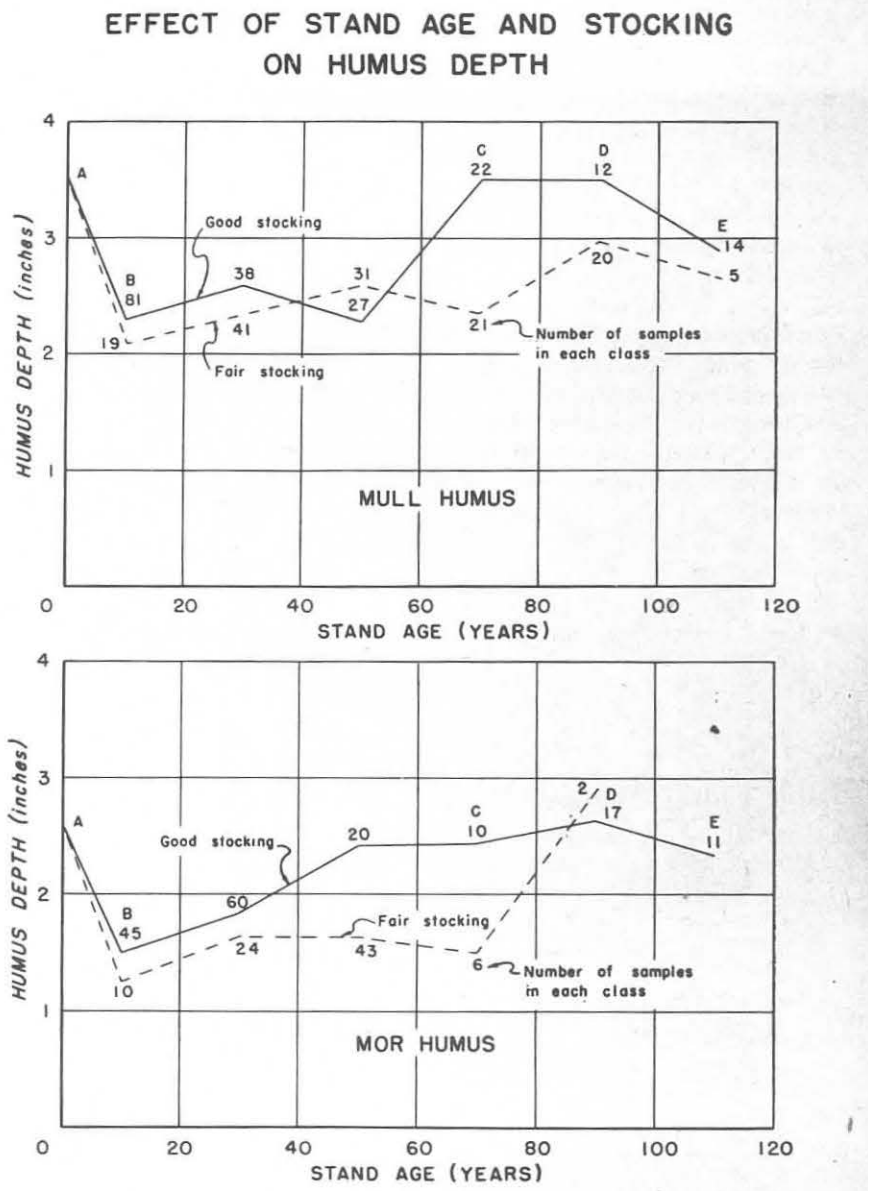
EFFECT OF STAND AGE AND STOCKING ON HUMUS DEPTH
HUMUS DEPTH (inches)
STAND AGE (YEARS)
Good stocking
Fair stocking
Number of samples in each class
MULL HUMUS
MOR HUMUS
A
B
C
D
E
NOTE: A, Humus depth of former stand, prior to logging. A-B, Period of organic decomposition following logging. B, Point where decomposition and deposition are equal. B-C, Period of greatest humus development. C-D, Period of greatest humus depth. D-E, Decrease of humus depth due to overmature stand.

FIG. 1.—Effect of stand age and stocking on humus depth.

Stocking.—The effect of stocking is shown in Figure 1. Though data for poorly stocked stands are lacking, conclusions may be drawn from the comparison of good stocking with fair stocking. At a given age, humus depths tend to be greater under well-stocked stands. Stand density exerts its influence on humus development in several ways. Heavier stocking means greater leaf fall, consequently more organic matter is returned to the forest floor each year; a more dense canopy means less sunlight reaches the forest floor, hence lower temperatures and slower decomposition as lower temperatures create conditions less favorable for oxidation, which is a primary process of decomposition (*2*); a dense stand minimizes the erosive effects of wind. As a result, a deeper humus develops under good stock-

ing than under poorer stand conditions.

Logging.—The influence of logging on humus depth varies according to the severity of cutting. A clearcutting operation not only removes the source of humus-building materials, but allows accelerated decomposition and erosion to take place. The forest floor decreases in depth until the rate of accumulation from the new stand begins to overbalance the rate of decomposition. Figure 1 shows the age at which this occurs, according to stocking conditions and humus type.

Though no data are available, the amount of advance reproduction present would seem to be an important factor in the rate of humus decrease. It is not yet known whether better humus conditions can be maintained by frequent light cuttings or by less frequent, heavier cuttings. Here, the physical effects of logging operations would be an important consideration.

Fires and grazing.—Both fires and grazing may cause deterioration of the stand with a resulting decrease of humus; both may cause physical destruction of the humus layers. The degree of damage varies, however, with intensity and frequency or duration.

It was found that light burns destroyed only the dry litter, but had no apparent effects on the depth of the humus. Severe burns completely destroyed the organic layer. Frequent burns, though not severe, may eventually kill all forest cover; then the humus layers disappear, either by the forces of decomposition or through wind and water erosion following the removal of the protective cover. Humus measurements taken in burned areas revealed wide variations from one spot to another, probably because of the erratic nature of fire.

The direct effect of grazing is compaction or destruction of the organic layers by the trampling of the animals. In continuously and severely grazed stands, the effect of compaction may be such that the loose, granular structure of a coarse, medium, or fine mull type of humus becomes dense and compact, typical of a firm mull.

Of 173 grazed plots studied on the Allegheny watershed, 42 (24 percent) had a firm mull or no humus at the sampling point. However, of the 43 samples of firm mull encountered, 33 (77 percent) occurred in grazed woods. Here too, wide variations were found within a single woodlot, the greatest compaction being on the most travelled areas, and the least on inaccessible areas.

Topographic factors.—Slope, aspect, and topographic position[2] may have an influence on humus development, but the number of observations taken on the Allegheny watershed was insufficient to bring out any conclusive differences attributable to these factors. A significant trend was shown, however, that northeast slopes develop a deeper humus than other slopes. Since northeast slopes receive less intense sunlight and are cooler, this might be expected. Although a rather definite trend was found for mull humus, the data for mors showed no correlation. Table 1 illustrates the trends found. Only those age-stocking groups having a reasonable aspect distribution are listed.

The effects of microtopography on humus depth are more pronounced. In many places windthrown trees and decayed logs and stumps have created a series of minor depressions and humps. The action of wind and water tends to fill up the depressions with organic matter from the humps. In several places, depths of 14 inches of granular mor were recorded under a young pole timber stand. This accumulation of organic matter was not formed in place, but had been water-borne into a depression. Conversely, in several instances, no humus was recorded under old stands of mature trees because the sample points fell on small hillocks which were swept clean by the action of wind and water. As a result of such phenomena, humus depths ranging from 0 to 14 inches were observed within a distance of 6 feet.

Soil factors.—Soil depth and drainage[3] were found to have no apparent effect on either the type or depth of humus where the upper soil horizons were well drained. Where peat or muck types of humus had developed on poorly drained or permanently wet soils, the relationships observed on well-drained soils were not found.

TABLE 1.—INFLUENCE OF ASPECT IN DEPTH OF MULL HUMUS

Stand		None (level ground)		NE		NW		SE		SW		Average[1]
Age	Stocking	Samples	Depth	Samples	Depth	Samples	Depth	Samples	Depth	Samples	Depth	Depth
		Number	*Inches*	*Number*	*Inches*	*Number*	*Inches*	*Number*	*Inches*	*Number*	*Inches*	*Inches*
100	Good ...	6	2.35	6	3.65	5	2.68	5	2.22	..	..	2.73
81–100	Fair	8	2.40	11	2.85	4	2.28	..	..	3	2.77	2.58
21–40	Good ...	8	2.88	14	3.86	13	2.34	11	2.25	21	2.06	2.47
21–40	Fair	13	1.78	13	2.95	10	2.45	6	2.17	11	1.95	
Average[1]	Good ...	..	2.63	..	3.76	..	2.51	..	2.24	..	2 06	2.64
	Fair	..	2.09	..	2.90	..	2.37	..	2.17	..	2.36	2.37
Average, all stands[1].		..	2.35	..	3.33	..	2.44	..	2.21	..	2.26	2.52

[1] Unweighted.

[2] Topographic positions used: Ridge top, upper slope, lower slope, bottomland.

[3] Soil depth and drainage classes used: Deep, well-drained; shallow, well-drained; imperfectly drained; poorly drained; and permanently wet.

Inconclusive evidence indicates that a deeper humus layer will develop on medium than on light-textured soils and that decomposition of the humus following removal of the stand is more rapid on light-textured soils than on medium. This may be explained by the fact that water movement and the accompanying leaching of organic substances is faster in sandy soils than in those of finer texture.

Summary and Conclusions

Some of the important factors affecting the development of forest humus layers in the Northeast have been brought to light during the course of flood-control survey investigations being made in this region. Evidence has shown that the depth of humus increases with the age of stand until maximum foliage production is reached, and that humus depth is directly correlated with stand density. Although age is largely the expression of total organic matter accumulation, density (which is a measure of the amount of foliage) controls the balance between organic accumulation and decomposition. Logging, fire, and grazing have destructive effects on humus layers, depending on their intensity and frequency or duration. Evidence was found that northeast slopes develop deeper humus layers than other aspects and that microtopographic features caused extreme variations in humus depths. In addition, inconclusive evidence showed that less humus is likely to develop on sandy soils than on heavier-textured soils, other factors being equal.

With increasing emphasis being placed on watershed values of forested lands, effects of management practices on forest floor conditions require a closer attention by forest managers. On lands where control of the water resources is of vital concern, management should be directed, where silviculturally sound, toward maintaining well-stocked vigorous stands and avoiding unduly large canopy openings. The cutting of immature stands should be limited to improvement cuts, thinnings, or other measures that will insure perpetuation of a good forest cover. A high level of fire protection and restriction of grazing are essential to keep the forest floor in the most desirable condition for water infiltration and storage.

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